

## Overview of Biogenic VOC Emissions using the BEIGIS Model

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Development of effective ozone and fine particulate (PM<sub>2.5</sub>) control strategies in California requires accurate emission inventories of their precursor emissions, including biogenic volatile organic compounds (BVOCs) such as isoprene and monoterpenes. Due to the heterogeneity of vegetation landcover, species composition and leaf mass distribution in California, quantifying BVOC emissions in this domain requires an emission inventory model with region-specific input databases and a high degree of spatial and temporal resolution. In response to this need, the California Air Resources Board (CARB) has developed a GIS-based model for estimating BVOC emissions, called BEIGIS, which uses California-specific input databases with a minimum spatial resolution of 1 square km and an hourly temporal resolution.

The BEIGIS isoprene emission algorithm (Guenther et al. 1991, 1993) is of the form  $I = I_S \cdot C_L \cdot C_T$ , where  $I$  is the isoprene emission rate (grams carbon as isoprene per hour) at temperature  $T$  and photosynthetically active radiation flux  $PAR$ .  $I_S$  is a base emission rate (grams carbon as isoprene per gram dry leafmass per hour) at a standard temperature of 30 °C and PAR flux of 1000 :mol m<sup>-2</sup>s<sup>-1</sup>.  $C_L$  and  $C_T$  are environmental adjustment functions for PAR and temperature, respectively. The monoterpene emission algorithm adjusts a base monoterpene emission rate by a temperature function (Guenther et al. 1993). Methylbutenol (MBO) emissions are modeled with an algorithm developed by Harley et al. (1998) similar to that for isoprene. Dry leaf mass/ leaf area ratios, and base emission rates for isoprene, monoterpenes and MBO, are plant species-specific and assembled from the scientific literature. Modeled BVOC emissions for a given spatial domain therefore represent the contribution by various plant species (through their leaf mass and emission rates) to the total BVOC emissions.

The main inputs to BEIGIS are landuse and vegetation landcover maps, gridded leaf area indices (LAI) derived from AVHRR satellite data (Nikolov 1999), leaf area/dry leaf mass factors, base emission rates, and gridded hourly ambient temperature and light intensity data (CALMET or MM5). For urban areas, landuse/vegetation landcover databases were developed from regional planning agency data and botanical surveys. Natural areas are represented using the GAP vegetation database (also satellite-derived and air photo interpreted) developed by the U.S.G.S. Gap Analysis Program (Davis et al. 1995). Agricultural areas are represented using crop landcover databases developed by the California Department of Water Resources. Ground surveys have been funded by ARB to validate the satellite-derived vegetation landcover and LAI input databases used in BEIGIS.

BEIGIS assimilates spatial and temporal inputs and integrates BVOC emission algorithms within a geographic information system environment called ArcView. Outputs from BEIGIS are hourly-resolved emissions of isoprene, monoterpenes and MBO, gridded at a 1-km resolution. Emission fields are conveniently visualized and interpreted within the GIS environment. Output files are then formatted for assimilation by air quality models.

## Other VOC Emissions from Biogenics

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In addition to terpenes, isoprene, and MBO, other organic compounds are suspected of being emitted by vegetation. Guenther et al. (1994) estimate that the other VOCs (OVOCs) may comprise 8-73% of total VOC. As a first estimate for use in air quality modeling for southern California, we have assumed an OVOC value of 30% of measured VOC.

The speciation of OVOC has been recently addressed by Lamanna et al. (1999). Using factor analysis of VOC concentrations measured above a Sierra Nevada pine plantation, they identified several compounds as being at least partially biogenic: acetone, ethene, propene, hexanal, acetaldehyde, and methanol. Based on this work we have assumed the following profile for OVOCs:

methanol	50.038 %
acetone	38.480 %
acetaldehyde	8.719 %
ethene	1.315 %
hexanal	0.725 %
propene	0.723 %

## References

- Davis, F. W., P. A. Stine, D. M. Stoms, M. I. Borchert and A. D. Hollander. 1995. Gap analysis of the actual vegetation of California –1. The southwestern region. *Madrono* 42: 40-78.
- Guenther, A. B. R. K. Monson and R. Fall. 1991. Isoprene and Monoterpene Emission Rate Variability: Observations with eucalyptus and emission rate algorithm development. *Journal of Geophysical Research*. 96: 10799-10808.
- Guenther, A. B., P. R. Zimmerman, P. C. Harley, R. K. Monson and R. Fall. 1993. Isoprene and Monoterpene Emission Rate Variability – Model Evaluations and Sensitivity Analyses. *Journal of Geophysical Research*. 98(D7): 12609-12617.
- Guenther, A., P. Zimmerman, and M. Wildermuth. 1994. Natural volatile organic compound emission rate estimates for U.S. woodland landscapes. *Atmospheric Environment*. 94: 1197-1210.
- Harley, P., V. Fridd-Stroud, J. Greenberg, A. Guenther and P. Vasconcellos. 1996. Emission of 2-methyl-3-buten-2-ol by pines: A potentially large natural source of reactive carbon to the atmosphere. *Journal of Geophysical Research*. 103: 25479-25486.
- Lamanna, M.S., and A.H. Goldstein. 1999. In situ measurements of C<sub>2</sub>-C<sub>10</sub> volatile organic compounds above a Sierra Nevada ponderosa pine plantation. *Journal of Geophysical Research*. 99: 21247-21262.
- Nikolov, N. T. 1999. 1-km resolution database of vegetation leaf area index and canopy clumping factor for the western U.S.A. N&T Services. Oak Ridge, TN.